



IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of

Wachtler et al.

Serial No.: 09/788,075

Filed: 02/16/01

For: HDI LAND GRID ARRAY PACKAGED DEVICE HAVING ELECTRICAL
AND OPTICAL INTERCONNECTS

TI-17462.2

Examiner: Thai, Luan

Art Unit: 2827

DECLARATION TO OVERCOME CITED PATENT (37 C.F.R. § 1.131)

Assistant Commissioner for Patents

Washington, D.C. 20231

Dear Sir:

MAILING CERTIFICATE UNDER 37 C.F.R. §1.8(A)

I hereby certify that the above correspondence is being deposited with the
U.S. Postal Service as First Class Mail in an envelope addressed to:
Assistant Commissioner for Patents, Washington, D.C. 20231 on

Jay M. Cantor, Reg. No. 19,906

1. This declaration is to establish conception of the invention on a date prior to October 16, 1992, which is the first effective date of cited U.S. patent to Marcinkiewicz et al. (5,422,513) and diligence in constructively reducing the invention to practice from a date prior to October 16, 1992, which is the first effective date of cited U.S. patent to Marcinkiewicz et al. (5,422,513), until the filing date of the grandparent (07/966,645) of the present application, on October 26, 1992.

2. The individual making this declaration is Ronald O. Neerings, the attorney of record who drafted and subsequently filed the grandparent (07/966,645) of the present application, on October 26, 1992.

3. To establish the conception of the invention, true copies of the following are submitted as evidence:

Exhibit A - Invention Disclosure submitted by inventors to TI patent department

TI-17462.2 (1)

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OFFICE OF PETITIONS

on a date prior to October 16, 1992;

Exhibits B-D - Lab book notes of inventor Kurt P. Wachtler modifying invention in above disclosure, all dated prior to October 16, 1992;

Exhibits E-F - Documents prepared for disclosure to TI customers under NDA to illustrate possible application of invention, both dated prior to October 16, 1992;

4. To establish diligence in constructively reducing the invention to practice, true copies of the following are submitted as evidence:

Exhibit G - A true and correct copy of the E-mail message from Kurt Wachtler (one of the inventors) to Ron Neerings on March 6, 1992, notifying Ron Neerings of the potential of disclosure of the invention on October 12, 1992;

Exhibit H - A true and correct copy of a portion of the data storage of the computer system used by Ron Neerings showing that the last change to the application was made by Ron Neerings on October 19, 1992;

Exhibit I - A true and correct copy of the Application for United States Patent Declaration and Power of Attorney signed by the inventors; and

Exhibit J - A true and correct copy of the Assignment of Invention by the inventors.

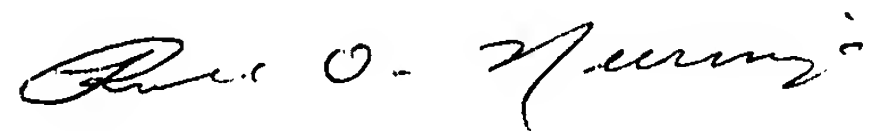
5. I hereby declare that I was in the process of drafting the application for TI-17462 (07/966,645) on at least March 15, 1992, a date prior to October 16, 1992, which is the first effective date of cited U.S. patent to Marcinkiewicz et al. (5,422,513), and I continued preparing the application until I made the last changes to the application on October 19, 1992 (see Exhibit H). I forwarded the final draft of the application to Kurt P. Wachtler; David N. Walter; and Larry J. Mowatt on October 19, 1992 for their review and approval. Kurt P. Wachtler approved the final draft of the application on October 21, 1992 (see Exhibits I & J). David N. Walter and Larry J. Mowatt approved the final draft of the application on October 23, 1992. I filed the application for TI-17462 (07/966,645) with the United States Patent and Trademark Office on October 26, 1992 upon receiving the signed Application for United States Patent Declaration and Power of Attorney (see Exhibit I) and Assignment (see Exhibit J) from the inventors.

5. This declaration is submitted prior to final rejection.

6. As a person signing below:

I hereby declare that all statements made herein on my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon

Respectfully submitted,

A handwritten signature in cursive script, appearing to read "Ronald O. Neerings".

Ronald O. Neerings

Date:

TI INTERNAL DATA
INVENTION DISCLOSURE

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1. What is the invention about (one sentence)?

This invention combines various electronic packaging techniques in a unique way to create a very thin, electrically and thermally high performance package for single or multiple semiconductor devices.

2. What is the problem solved by your invention?

The electronic industry is continuously demanding electronic packaging to fully utilize the semiconductor device's operational speed. The package must manage thermal requirements that are driven by the heat generated by the semiconductor devices and the constant reduction in the size of the final electronic system. Therefore, the package itself must displace minimal volume when assembled into the electronic system. Also, the ideal package design and material selection should support the reduction of assembly process defects and not require new assembly capital and tooling.

3. What is your solution to the problem described above?

To solve these problems, this invention modifies existing High Density Interconnect (HDI) multichip module technology (ref. Fig A) to electrically interconnect the semiconductor device (1A) to an array of pads (2A) on the thin film overlay's (3A) top layer. The uniqueness of this invention is the resulting form of the packages and system assemblies gained from modifying the HDI technology through the utilization of the following materials and design techniques: industry available heat sinks (4A), substrate material tailored for optimum thermal and mechanical properties (5A) and various techniques of attaching the package to the printed wiring board (7A), for example, solder balls (6A), conductive adhesive, elastomeric connectors or conventional surface mount peripheral leads.

The electrical path through this package begins with the signal coming off the printed wiring board (PWB), travels through the solder balls, through circuits in the thin film overlay and into the die. A signal returning to the PWB propagates through this sequence of material in reverse order. This path is the shortest and fastest path possible for a packaged semiconductor. The thin film overlay may be designed to accommodate special electrical requirements, for example high speed transmission lines, by adding electrical protective layers in the thin film overlay. The thermal path for the die to the air is also very short because the die is attached directly to the substrate and the heat sink is attached directly to the back side of the substrate.

Comparison of the impact on packaging volume must be performed at the system level because there are alternative techniques to this invention that are smaller and thinner. This invention will be comparable to or out perform most alternatives when the total space on a PWB is defined to accommodate these alternatives, the techniques are defined for mechanical protection, the attachment of a heat sink is demonstrated and the assembly cost and yields are understood.

Initial solder ball, land grid array package assembly information indicates the level of defects to be below that of alternative package designs for high pin count devices. The assembly of these land grid array packages was performed with existing surface mount assembly capital and with minimal new tooling.

4. What is different about your solution from others' solutions to the same problem?

Non-HDI Alternatives:

There are numerous alternative solutions to these problems which include the packaging in Figure B. Each alternative has their own relative strengths and weaknesses. It is beyond the scope of this disclosure to address all these alternatives. This invention is designed to outperform these industry standard techniques when the semiconductor device is large, fast and hot. It also has the potential to outperform packaging techniques for consumer electronics due to characteristics described below.

In general the land grid array will require a lower cost PWB for the next level interconnect because the pad array configuration puts less demand on the PWB's physical feature sizes and tolerances. There are alternative land grid array package designs (ref.Fig.C). But, in addition to longer electrical path, these alternatives do not have the thermal path advantages of this invention.

HDI Alternatives:

Existing utilization of the HDI technology did not take advantage of the thin film overlay's top metal to be the site of a land grid array for the electrical interface to the next level packaging. The land grid array technology has the potential to reduce assembly defects and utilize existing assembly capital. This invention also includes unique package design and material selection to meet high performance packaging requirements as well as low cost portable electronic applications.

The standard substrate material for a HDI multichip module is alumina. But, the substrate can be designed to utilize various materials to customize the package to a product application.

The substrate may be constructed of molded plastic (Ref. Fig. D) in a similar manner 3-dimensional PWB's and antennas are manufactured today. This high volume manufacturing technique will reduce cost and increase manufacturing capacity to support high volume applications. This molding technique offers outstanding flexibility advantages in product design. Thermal dissipation can be enhanced if thermal vias or heat slugs (1D) are also molded into the substrate material. A metal lead frame (2D) or tape automated bonding (TAB) type material (2D) may be molded around the perimeter of the semiconductor device as an alternative to the land grid array design. The subsequent thin film overlay process would provide the electrical connections from the semiconductor device to the lead frame. It may be lower cost and result in higher reliability if the semiconductor device was molded into the package in the same step we mold the substrate, with or without a heat slug or lead frame. This would decrease handling damage and manufacturing operation steps. The mold may be designed so the molding compound would cover the face of the semiconductor device (3D). The thickness would be the same thickness as the current thermal plastic material used in the first manufacturing step for today's HDI multichip modules.

Another variation of this invention allows this package to be designed for portable electronic products (Ref. Fig. E), for example, a cellular phone or pocket computer. The solder balls on the top layer of the thin film overlay would be replaced with an array of metal pads (1E) to accommodate pressure contact alternatives. It is possible for a conductive path (2E) to be built through the substrate to allow an alternative electrical path off the back side of the package. The metal pads on either side of the module would make electrical contact to the various types of hardware (ie., a flexible PWB (3E), a rigid PWB (4E) or a display panel (5E)) through conventional solder, conductive adhesive or some type of Z-axis, electrically conductive material (6E). An ideal assembly approach would be for the package to "snap-in" the other system hardware and establish electrical contact through a pressure sensitive media. To apply the pressure either the substrate would be designed with features (7E) that would pressure load the package into the system or the system would have the pressure inducing feature. This "snap-in" feature would allow easy system hardware upgrades or a product designed for changing out packages for alternative software applications.

Another interesting, possibly lower cost, substrate material is PWB laminate (Ref. Fig. F, 1F). The cavity (2F) in the PWB substrate may be designed to expose a metal base (3F) for the die attach. This metal may be selected to customize the substrate thermal expansion rate and maximizing the overall package heat dissipation characteristics.

The material combinations are endless, but another application to include in this disclosure is the utilization of artificial diamond

material for the substrate. This would take full advantage of the unique HDI technology characteristics. It is conceivable to manufacture artificial diamond material in the shape of a substrate and achieve an extremely high thermally conductive package.

5. What are the advantages of your solution?

Smaller, thinner, electrically faster, higher heat dissipation and adaptable to a wide range of electronic packaging applications. Higher reliability due to elimination of wire bonds or TAB attachment solder joints. Potentially, lower cost because of reduction in manufacturing and assembly process steps.

6. What TI products, processes, projects or operations can use your invention?

The most likely initial product will be a single component package for high performance ASIC's, programmable gate arrays or digital signal processors. The manufacturing of this single component package will stabilize the raw material properties and the process variables. This stability in manufacturing will have a direct and positive impact on our multichip module products.

This package has been identified as a critical path in support of the Ericsson ATM program. The Sun Viking and Spitfire programs will also be affected by this invention. As the invention matures, the array I/O feature would be applied to multiple chip products. With the use of a low cost, plastic substrate, this may be applicable to portable electronics modules, ie., pocket computers and telephones.

7. Has the invention been talked about or written about to anyone outside of TI? (Y/N) Y When? [REDACTED] & [REDACTED]
If planned - when: [REDACTED] (Catalog, advertising, data book, application note, conference paper, magazine article, TI TJ, proposal document e.g. to U.S. government.) Was there a nondisclosure agreement (NDA)? (Y/N) Yes, FOR BOTH.

8. Has a TI product with the invention been introduced, quoted, sampled or shipped? (Y/N) No When? [REDACTED].
If planned--when? [REDACTED].

9. Was the invention conceived or first actually reduced to practice in the performance of experimental, developmental, or research work called for by a government contract or subcontract? (Y/N) NO Contract #: [REDACTED]

10. What is your suggested title for this invention?

HDIP - High Density Interconnect Package

THE INVENTION DESCRIBED BY THIS INVENTION DISCLOSURE INCLUDING TEN PAGES IS SUBMITTED PURSUANT TO MY EMPLOYMENT AGREEMENT WITH TEXAS INSTRUMENTS INCORPORATED OR A TI SUBSIDIARY (SPECIFY).

(Signed) Kurt P Wachtler
Date [REDACTED]

(Printed) Inventor: Kurt P Wachtler

Address: 147 Hidden Circle, Richardson, Tx 75081

Citizenship: U.S.A. PC Drop/Mail Station 29

Employee #: 129501 TI Group/Division/Dept. CMS / 14 /

Phone #: 945-3556 Supervisor Mike Valek

Supervisor PC Drop/Mail Station 129

(Signed) David N. Walter
Date [REDACTED]

(Printed) Inventor: DAVID N. WALTER

Address: 1516 SPRINGTREE CIR., RICHARDSON, TX 75082

Citizenship: U.S.A. PC Drop/Mail Station PCSI / 956

Employee #: 696755 TI Group/Division/Dept. ATC / MPS / MCM Foundr.

Phone #: 995-0648 Supervisor Larry Mowatt

Supervisor PC Drop/Mail Station PCSI / 956

(Signed) Larry J Mowatt
Date [REDACTED]

(Printed) Inventor: LARRY J. MOWATT

Address: 1405 MARIGOLD DR., ALLEN, TX. 75002

Citizenship: USA PC Drop/Mail Station MS 956 / PCSI

Employee #: 157715 TI Group/Division/Dept. DSEG / ATC / MPS

Phone #: 214 995 1287 Supervisor Mike Fleener

Supervisor PC Drop/Mail Station MS 479

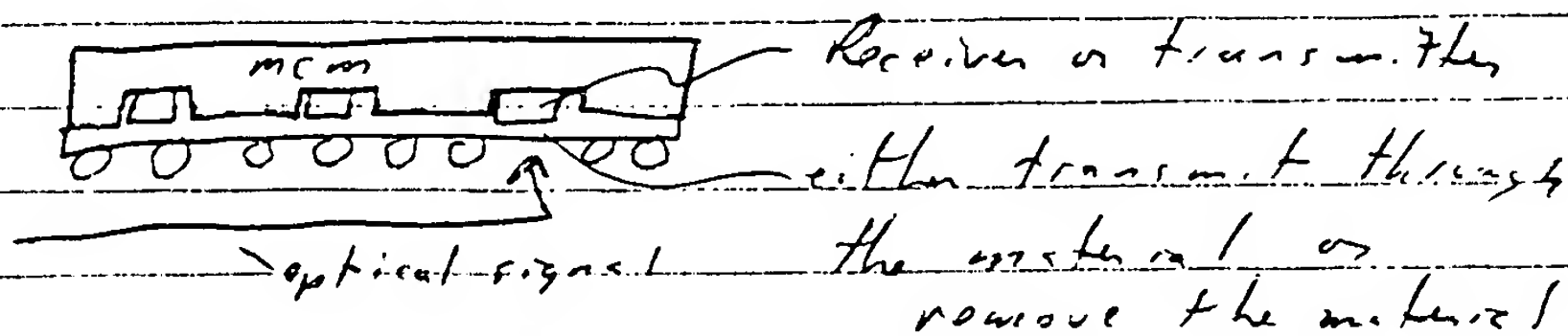
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7/1/87

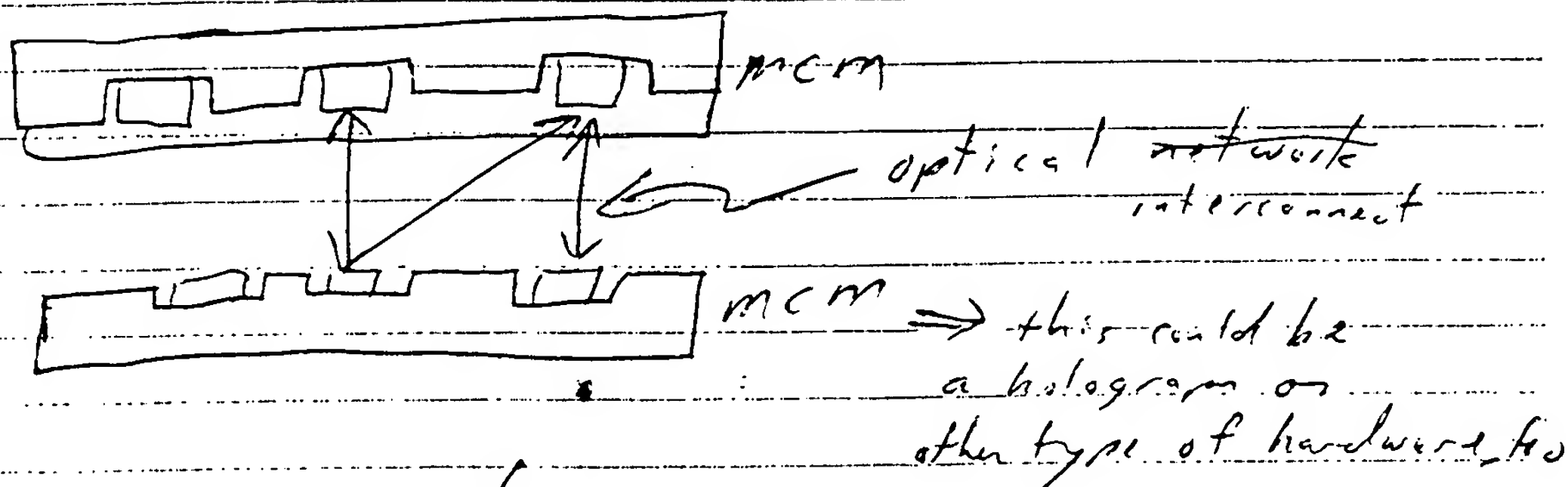
Reference note, on HDI package, pages 137-149

Another variation to the theme would be to use the HDI package as an optical interconnect.

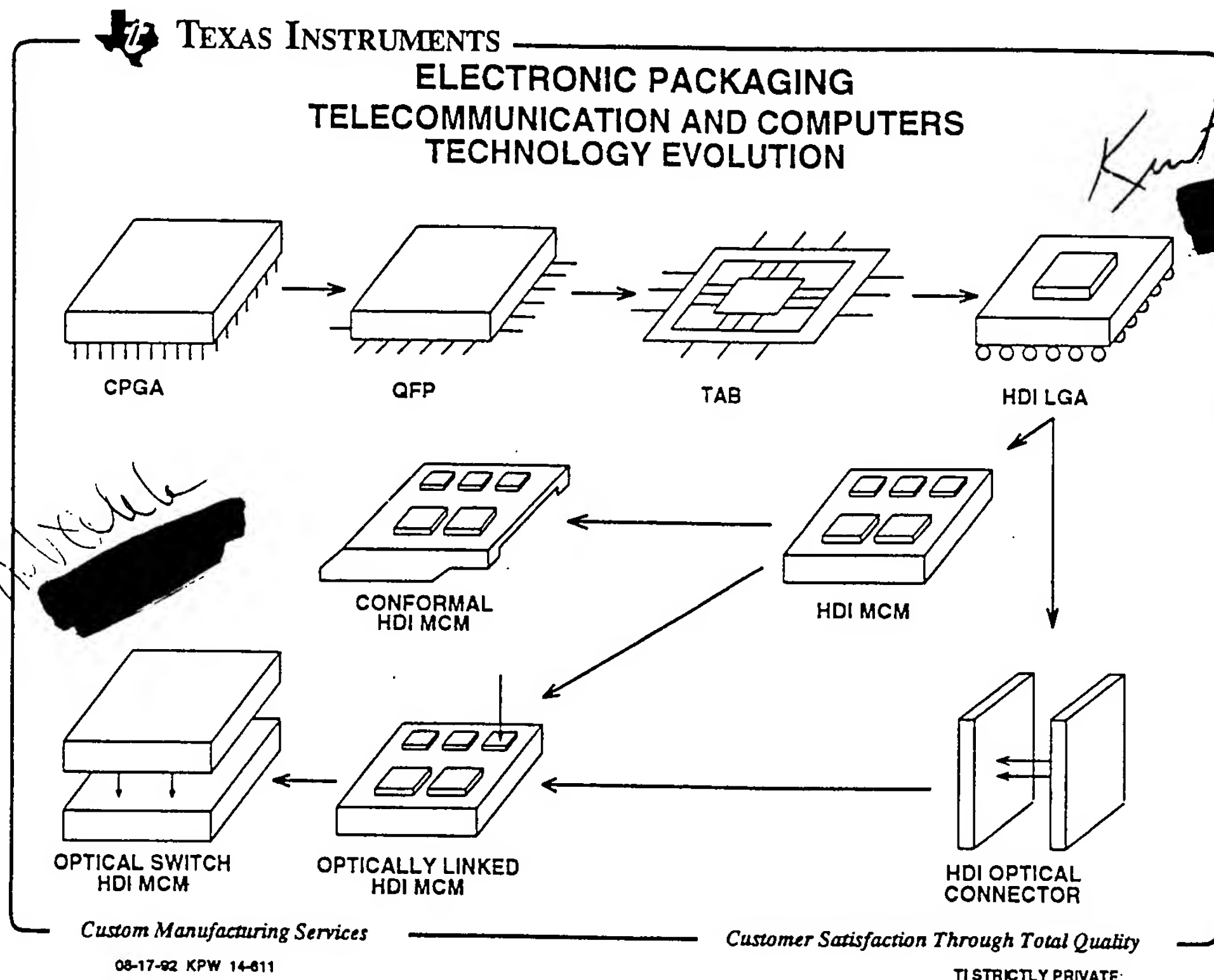


The mcm top metal layer can be imaged with respect to the position of the receiver chip's location and the mcm/PWB pads & solderballs would be optimized to improve assembly alignment.

This technology would lead directly to optical communication between mcm's for faster interconnections. see copy of notes below.



Kurt P. Wachtel
M. V. Ball



This chart shows how TI can leverage the fundamental HDI technology into a whole product line. We can start up the factory with a lower technology approach than a full mcm by productizing the LGA single component package. The HDI technology application brought to us by the person from the University of South Florida, on 8/19/92 would fit in well as a low tech start on the optical interconnect products. They will complement themselves by evolving into an optically linked mcm and eventually a full interconnected mcm system.

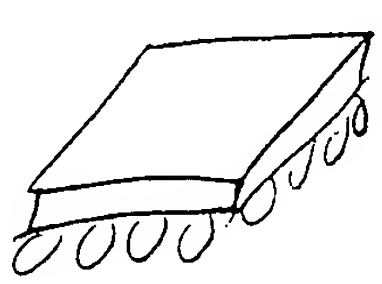
optically

Kurt P. Wachtel

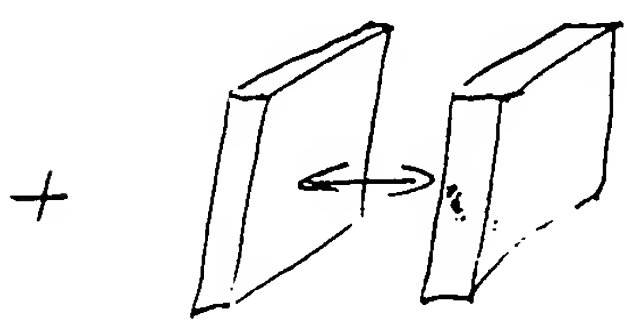
M. W. W.

~~_____~~ HDI Single component package evolution to
multichip/optically coupled modules _____

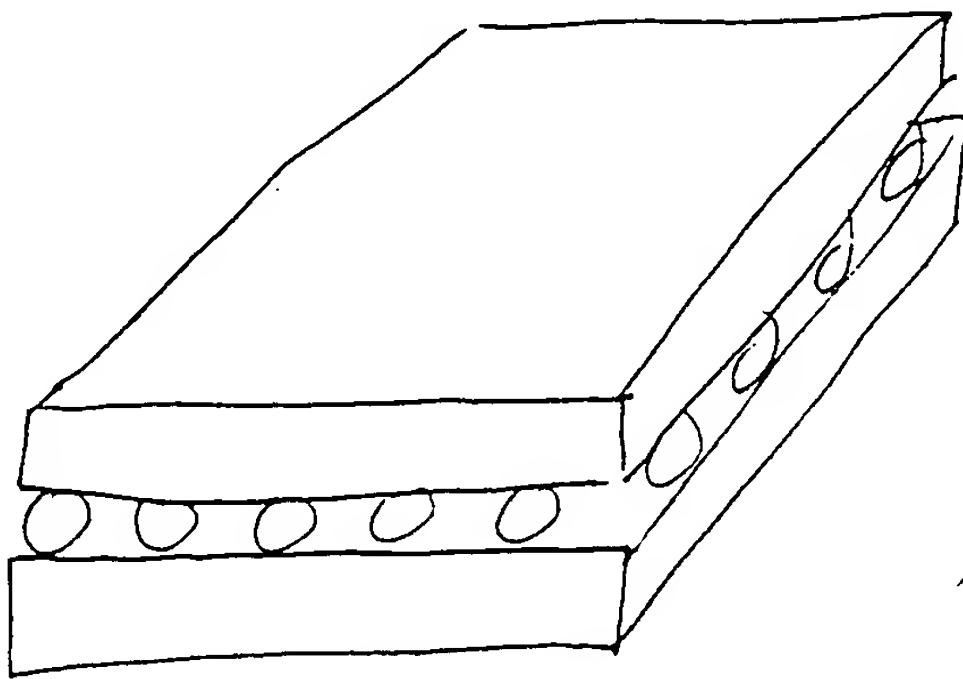
The technology planned to be demonstrated for a
single chip HDI package can be extended to multichip.



} single package with solder balls



+ } optical transmission from one HDI
package to another



} two HDI multichip
packages self aligned
with solder balls. Light will
transmit from one module
to the other. One or both

of the modules will have emitters, receivers,
diffraction/~~reflect~~ refraction optical elements or even mirrors
(i.e., TI's DMO components). The application would
include high speed switching of telecommunication
signals or other types of "free space" optical connections.

EXHIBIT D

WORK OF:

Kurt P. Wachtel

DATE: ~~_____~~

I witness this document and understand its contents.

NAME _____

Date _____

I witness this document and understand its contents.

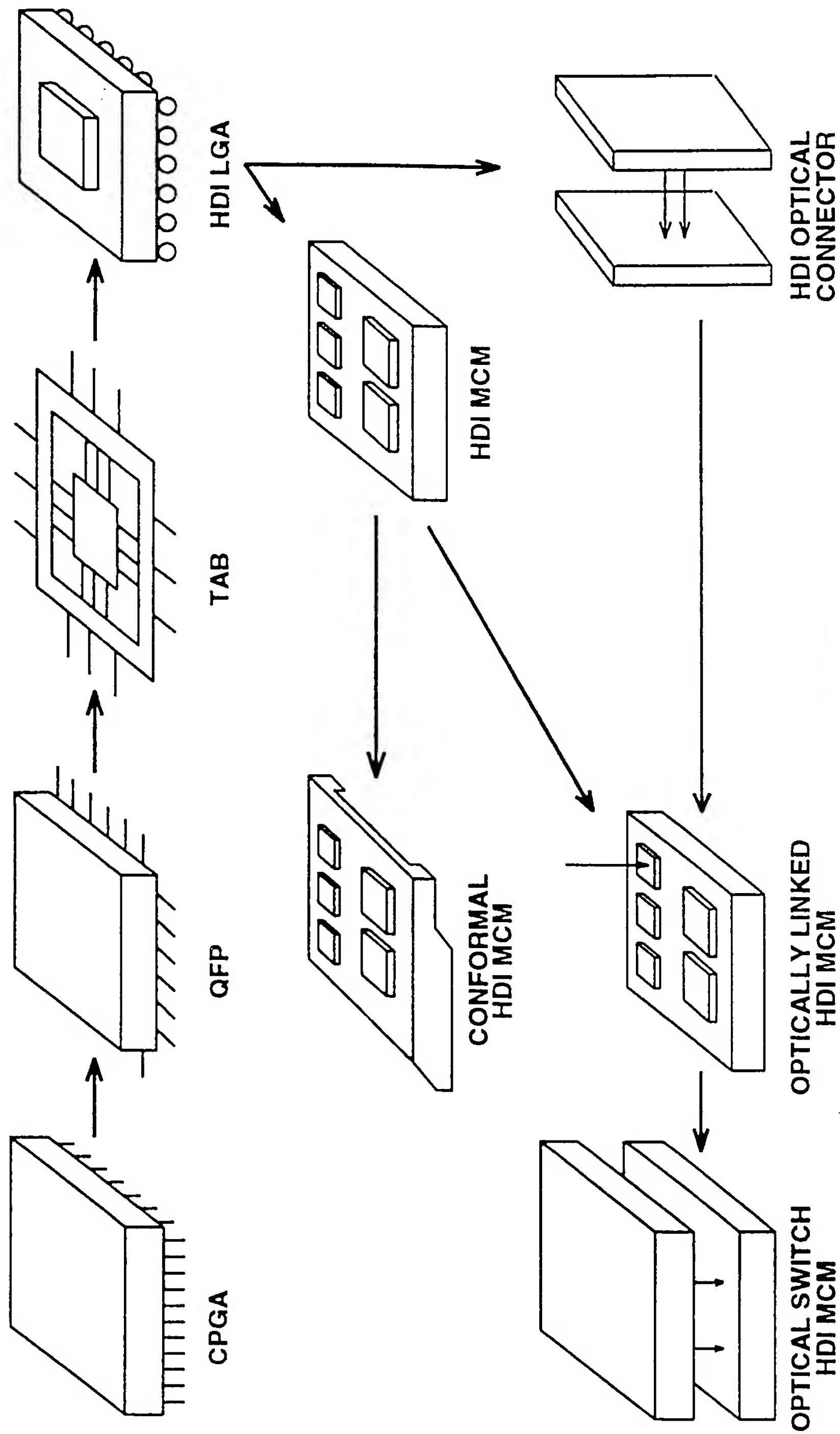
NAME _____

Date _____



TEXAS INSTRUMENTS

ELECTRONIC PACKAGING TELECOMMUNICATION AND COMPUTERS TECHNOLOGY EVOLUTION



Custom Manufacturing Services

Customer Satisfaction Through Total Quality

TPW 14-611

TI STRICTLY PRIVATE

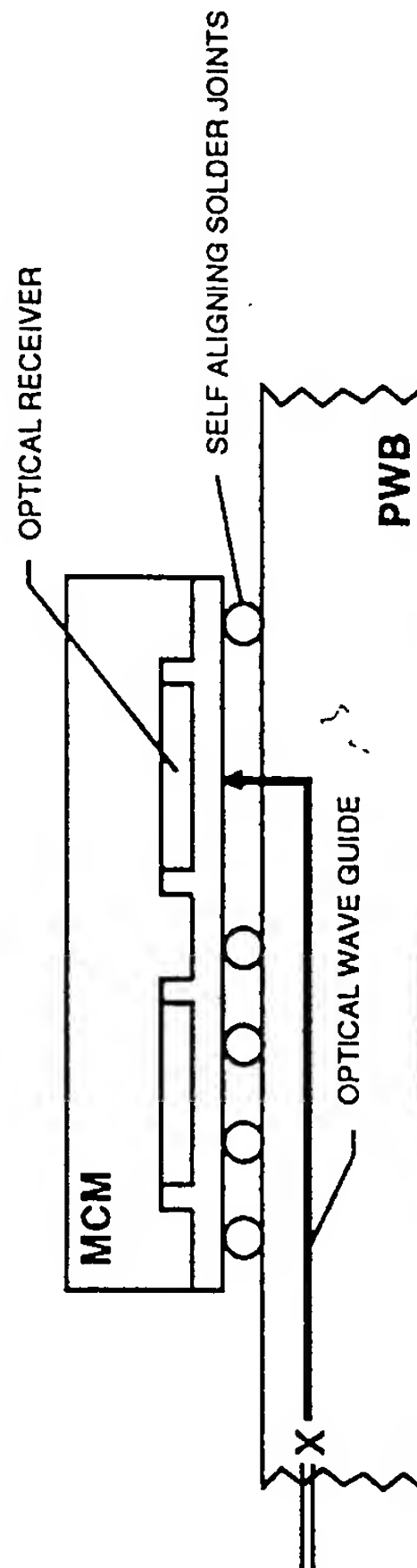


TEXAS INSTRUMENTS

ELECTRONIC PACKAGING MCM OPTICAL INTERCONNECT

CUSTOMER:

- * TELECOM ATM2 SYSTEMS
- * ANY OPTICAL INTERNETWORKING SYSTEM



PACKAGE AND ASSEMBLY CHARACTERISTICS:

- * TECHNOLOGY EVOLVES FROM HDI'S SINGLE COMPONENT PACKAGE AND OPTICAL CONNECTOR.
- * MCM TOP METAL PATTERN ALIGNED TO BURIED RECEIVER CHIP LOCATION.
- * PWB AND MCM PAD/SOLDER BALL OPTIMIZED FOR ALIGNMENT ACCURACY.

DEVELOPMENT RESOURCES:

- * HDI FOUNDRY
- * CRL PHOTONICS LAB
- * NATIONAL LABS
- * CONNECTOR SUPPLIER
- * NCMS
- * SIA
- * MCM INITIATIVE

KPW 14-611

Custom Manufacturing Services

TI STRICTLY PRIVATE

Customer Satisfaction Through Total Quality

-MSG M#= 347923 FR=KPW TO=RON4 SENT=10/06/92 09:42 AM
R#=106 ST=C DIV=001 CC=00171 BY=KPW3 AT=10/06/92 09:42 AM

To: Larry Mowatt	MOWT	Milton Buschbom	SMDD
Masood Murtuza	MURQ	Mike Valek	MHV
Ron Neering	RON4		

From: Kurt Wachtler KPW3

Subj: HDI SINGLE COMPONENT BALL GRID ARRAY PACKAGE

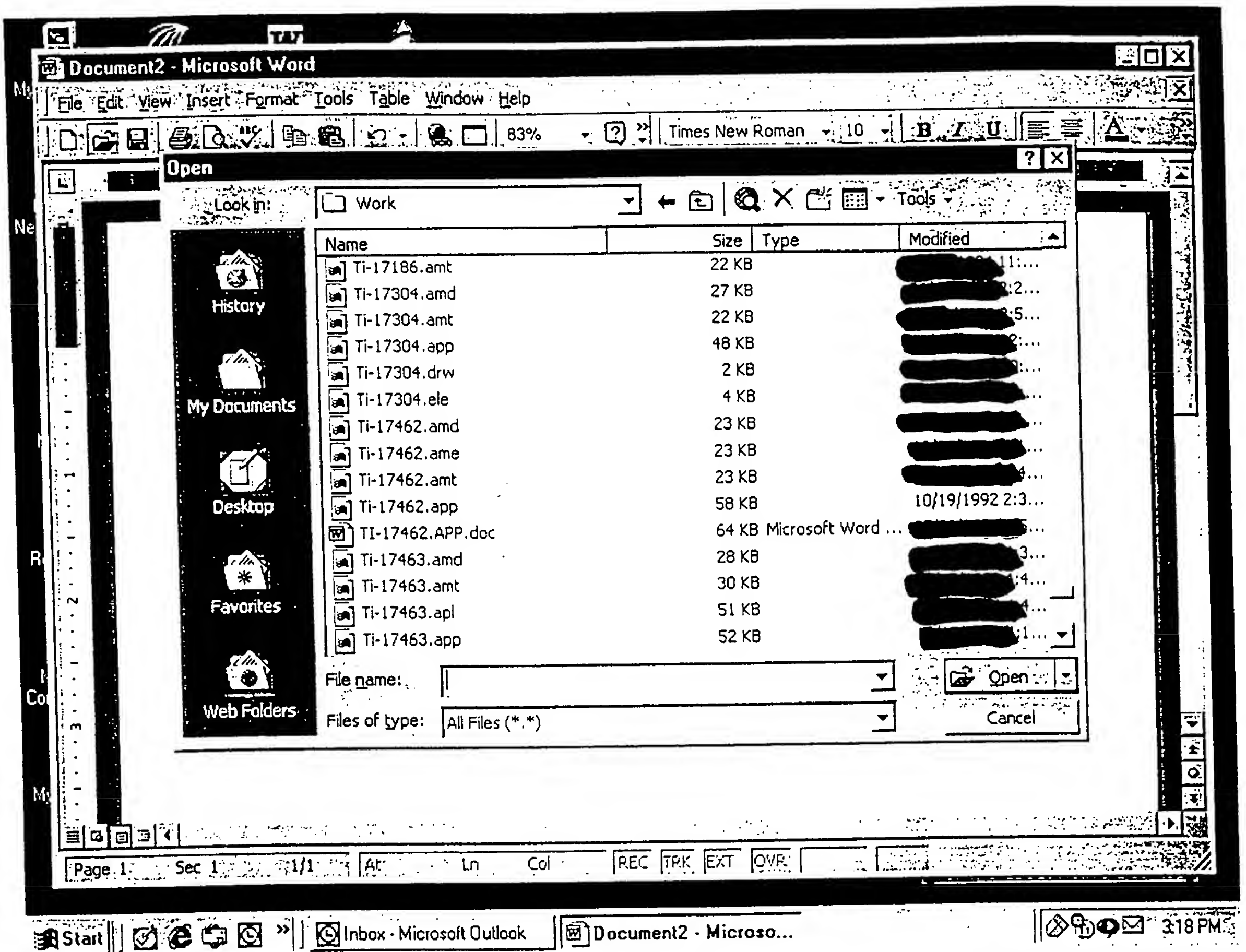
SUNIL KAUL OF SUN WANTS TO DISCLOSE THE HDI PACKAGE TO MOTOROLA DURING A TELECONFERENCE ON 10/12 IN ORDER TO PUT IT ON THE OFFICIAL ALTERNATIVE PACKAGE LIST. FURTHER DISCUSSION WILL FOLLOW IN A MEETING LATER IN THE MONTH.

MASOOD, MAY I GET A COPY OF THE NDA WE ARE UNDER WITH SUN FOR THE SPITFIRE PROGRAM SO I MAY BE SURE I UNDERSTAND THE AREAS INCLUDED.

I WOULD LIKE TO GO AHEAD WITH THIS IF WE ARE COVERED.

REGARDS,
KURT

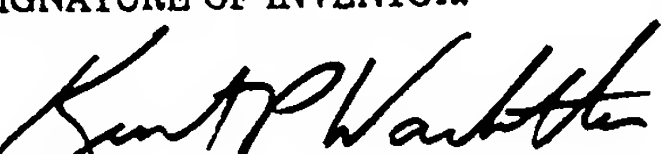
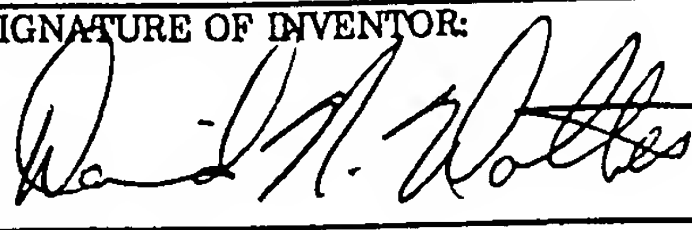
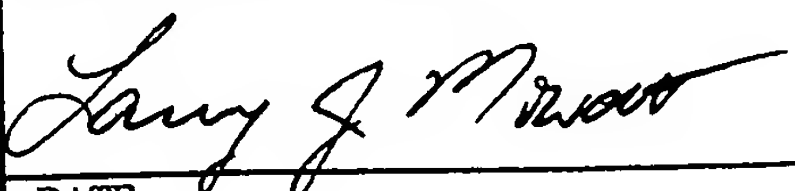
EXHIBIT G



APPLICATION FOR UNITED STATES PATENT
DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I declare that my residence, post office address and citizenship are as stated below next to my name; that I verily believe that I am the original, first and sole inventor if only one name is listed below, or an original, first and joint inventor if plural inventors are named below, of the subject matter which is claimed and for which a patent is sought on the invention entitled as set forth below, which is described in the attached specification; that I have reviewed and understand the contents of the specification, including the claims, as amended by any amendment specifically referred to in the oath or declaration; that no application for patent or inventor's certificate on this invention has been filed by me or my legal representatives or assigns in any country foreign to the United States of America; and that I acknowledge my duty to disclose information which is material to the patentability of this application in accordance with Title 37, Code of Federal Regulations, section 1.56;

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

TITLE OF INVENTION: HDI LAND GRID ARRAY PACKAGED DEVICE HAVING ELECTRICAL AND OPTICAL INTERCONNECTS		
POWER OF ATTORNEY: I HEREBY APPOINT THE FOLLOWING ATTORNEYS TO PROSECUTE THIS APPLICATION AND TRANSACT ALL BUSINESS IN THE PATENT AND TRADEMARK OFFICE CONNECTED THEREWITH Ronald O. Neerings, Reg. No. 34,227; Robby T. Holland, Reg. No. 33,304; James C. Kesterson, Reg. No. 25,882; William E. Hiller, Reg. No. 18,803; and Richard L. Donaldson, Reg. No. 25,673.		
SEND CORRESPONDENCE TO: Ronald O. Neerings Texas Instruments Incorporated P. O. Box 655474, MS 219 Dallas, Texas 75265		DIRECT TELEPHONE CALLS TO: Ronald O. Neerings (214)995-1804
NAME OF INVENTOR: (1) Kurt P. Wachtler	NAME OF INVENTOR: (2) David N. Walter	NAME OF INVENTOR: (3) Larry J. Mowatt
RESIDENCE & POST OFFICE ADDRESS: 147 Hidden Circle Richardson, Texas 75081	RESIDENCE & POST OFFICE ADDRESS: 1516 Springtree Circle Richardson, Texas 75082	RESIDENCE & POST OFFICE ADDRESS: 1405 Marigold Drive Allen, Texas 75002
COUNTRY OF CITIZENSHIP: USA	COUNTRY OF CITIZENSHIP: USA	COUNTRY OF CITIZENSHIP: USA
SIGNATURE OF INVENTOR: 	SIGNATURE OF INVENTOR: 	SIGNATURE OF INVENTOR: 
DATE: 10/21/92	DATE: 10/23/92	DATE: 10/23/92

ASSIGNMENT

WHEREAS, I, the undersigned inventor (or one of the undersigned joint inventors), of residence as listed, having invented certain new and useful improvements as below entitled, for which application for United States Letters Patent is made, the said application having been executed on the date set forth below; and


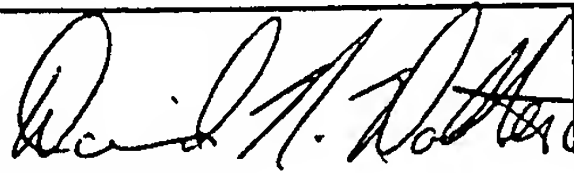

WHEREAS, TEXAS INSTRUMENTS INCORPORATED, a corporation organized and existing under the laws of the State of Delaware, with its principal office at 13500 North Central Expressway, Dallas, Texas 75265, is desirous of acquiring my entire right, title and interest in and to the said invention, and to the said application and any Letters Patent that may issue thereon;

NOW, THEREFORE, for good and valuable consideration, the receipt of which is hereby acknowledged, I hereby sell and assign to the said TEXAS INSTRUMENTS INCORPORATED, its successors and assigns, my entire right, title and interest in and to the said invention and in to the said application and all patents which may be granted therefor, and all divisions, reissues, substitutions, continuations, and extensions thereof; and I hereby authorize and request the Commissioner of Patents and Trademarks to issue all patents for said invention, or patent resulting therefrom, insofar as my interest is concerned, to the said TEXAS INSTRUMENTS INCORPORATED, as assignee of my entire right, title and interest.

I also hereby sell and assign to TEXAS INSTRUMENTS INCORPORATED, its successors and assigns, my foreign rights to the invention disclosed in said application, in all countries of the world, including the right to file applications and obtain patents under the terms of the International Convention for the Protection of Industrial Property, and of the European Patent Convention, and further agree to execute any and all patent applications, assignments, affidavits, and any other papers in connection therewith necessary to perfect such patent rights.

I hereby further agree that I will communicate to said TEXAS INSTRUMENTS INCORPORATED, or to its successors, assigns, and legal representatives, any facts known to me respecting said invention, and at the expense of said assignee company, testify in any legal proceedings, sign all lawful papers, execute all divisional, continuation, reissue and substitute applications, make all lawful oaths, and generally do everything possible to aid said TEXAS INSTRUMENTS INCORPORATED, its successors, assigns and nominees to obtain and enforce proper patent protection for said invention in all countries.

IN WITNESS WHEREOF, I hereunto set hand and seal this day and year;

TITLE OF INVENTION	HDI LAND GRID ARRAY PACKAGED DEVICE HAVING ELECTRICAL AND OPTICAL INTERCONNECTS		
SIGNATURE OF INVENTOR AND NAME	 Kurt P. Wachtler	 David N. Walter	 Larry J. Mowatt
DATE	10/21/92	10/23/92	10/23/92
RESIDENCE (City, County, State)	Richardson, Dallas Texas	Richardson, Dallas Texas	Allen, Collin, Texas
DATE APPLICATION EXECUTED	10/26/92	10/26/92	10/26/92

After recording returning Assignment to:

RECORDED
PATENT AND TRADEMARK
OFFICE

OCT 26 1992

Ronald O. Neerings, Esq.
Texas Instruments Incorporated
P.O. Box 655474, M/S 219
Dallas, TX 75265